N-Management using Nitrification Inhibitor DMPP to Reduce Nitrogen Oxide Emissions in Mediterranean Winter Barley

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INTRODUCTION

Increasing nitrogen (N) use efficiency during crop production is paramount both from an economic and environmental perspective. A proposed measure to achieve it is to split the addition of fertilizers with more than one application. For a winter crop under Mediterranean climatic conditions, the most common application pattern consists of a basal fertilization (October-November) and a top-dressing (February-March). However, this management practice may have significant N losses, initially due to NO_3^- leaching by autumn rainfalls, and in the form of N_2O and NO at top-dressing due to the mild and wet conditions of this period, which favor both nitrification and denitrification. Nitrification inhibitors (NIs) such as DMPP, are known to slow down the oxidation of ammonium (low mobility ion) to nitrate (high mobility ion). As a consequence, NI use represents an opportunity to mitigate N losses, as NO_3^- leaching and N_2O and NO emissions (Sanz-Cobena et al., 2012). The aim of this study was to evaluate best management practices to reduce N oxides emissions with DMPP in rainfed Mediterranean agroecosystems. In this context, we set up a field experiment with a barley (*Hordeum vulgare* L.) crop.

METHODS

Table 1. Fertilizer treatments

Treatment	Fertilizer		N rate (kg N ha^{-1})		
	First fertilization	Second fertilization	First fertilization	Second fertilization	Total
Control	-	-	0	0	0
N+S	NPK (12+12+17)	ASN	40	80	120
N+E26	NPK (12+12+17)	ENTEC 26	40	80	120
E+E26	ENTEC (12+12+17)	ENTEC 26	40	80	120
O+N	-	NPK (24+8+7)	0	120	120
O+E	-	ENTEC (24+8+7)	0	120	120

ASN, ammonium sulfate nitrate (26% total N = 18.5% NH_4^+-N + 7.5% NO_3^--N)

NPK (12+12+17), Nitrofoska® special (12% total N = 7% NH_4^+-N + 5% NO_3^--N)

NPK (24+8+7), Nitrofoska® (24% total N = 13.5% NH_4^+-N + 10.5% NO_3^--N)

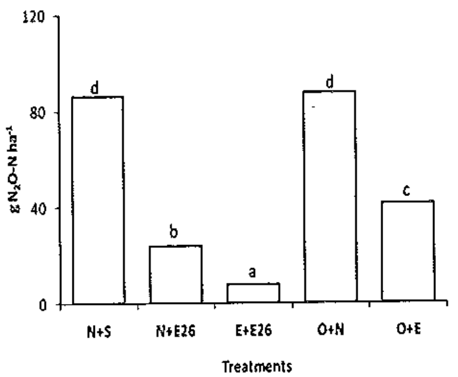
ENTEC® 26, (ASN + DMPP)

ENTEC® (12+12+17 and 24+8+7), (NPK + DMPP)

The experiment was carried out at "El Encín" Field Station (40°32'N, 3°17'W) in Madrid. A randomized complete block design with four replicates was established, each plot covering an area of 64 m^2 (8m x 8m). The different fertilizer treatments are shown in Table 1. The proportion of NI in the ENTEC® fertilizers was 0.8% of the NH_4^+-N. The N treatments were applied at sowing (First fertilization, 28th November) and as a top-dressing (Second fertilization, 6th March). Nitrogen oxide fluxes were quantified by gas chromatography (N_2O) and chemiluminescense detection (NO) (Abalos et al., 2012). Soil NO_3^- and NH_4^+ were colorimetrically analyzed. Soil moisture was monitored using frequency domain reflectometry (FDR) probes, and drainage was calculated by applying the simplified one-dimensional (vertical) water balance equation (Sanz-Cobena et al., 2012). Differences between treatments in the cumulative emissions were analysed using analysis of variance ($P < 0.05$, ANOVA).

RESULTS AND DISCUSSION

The N losses through NO_3^- leaching were negligible in our study. This could be due to the low rainfall during the crop period, 90 mm in total, the high water-holding capacity of the fine textured soil surface and the water removed by the barley roots, which can be as deep as 0.9 m. Lower N_2O and NO emissions were measured from DMPP treated soils (Fig. 1). The reduction was largely explained by the lower soil NH_4^+ and NO_3^- content of these plots (data not depicted), as a result of the nitrification inhibition (Sanz-Cobena et al., 2012). Overall, the lowest emissions were measured when the inhibitor was applied both at basal and top-dressing fertilizations (E+E26). Splitting fertilizer application with DMPP at top-dressing (N+E26) was a better strategy to reduce N_2O emissions than single fertilizer application with the inhibitor at top-dressing (O+E). Our results show that the active management of the nitrification inhibitor DMPP during crop production drives its efficiency to abate N losses. At the moment, the experiment is on the second year so further results will be incorporated to increase the consistency of our conclusions.



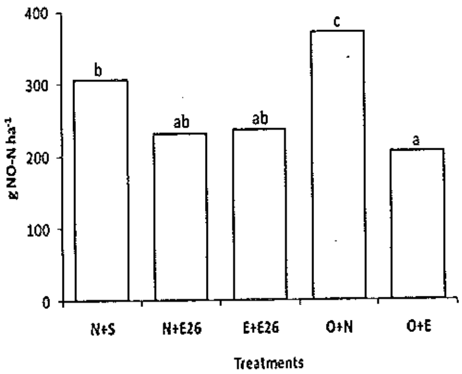


Fig. 1. Cumulative N_2O and NO emissions during the crop period. Significant differences ($P<0.05$, ANOVA) between treatments are indicated by different letters.

CONCLUSIONS

We have shown that the use of fertilizers with nitrification inhibitor DMPP can be considered a mitigation strategy for N oxide emissions under Mediterranean conditions. Its use is recommended both at basal and top-dressing fertilizations. Splitting fertilizer application it's environmentally a better management practice than single fertilizer application.

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